THE UNIVERSITY OF ALBERTA

SUMMER AND AUTUMN FOOD HABITS OF ISLAND AND MAINLAND POPULATIONS OF POLAR BEARS -- A COMPARATIVE STUDY

by

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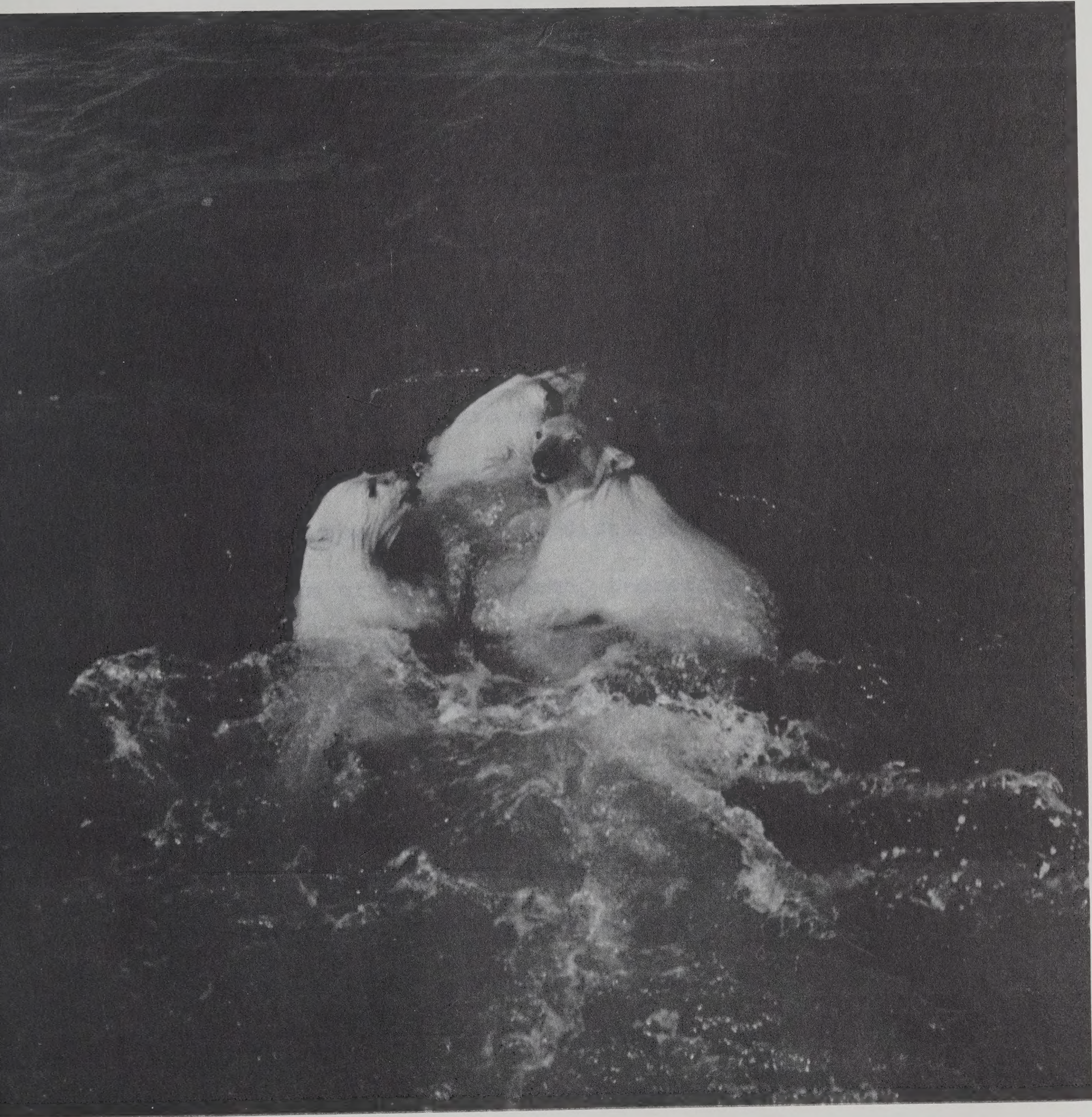

Abstract

Research on summer and autumn food habits of island and mainland populations of polar bears (*Ursus maritimus* Phipps) began in 1968 in conjunction with population studies undertaken on this species by the Canadian Wildlife Service.

Data on tagged bears suggest that bears resident in James Bay and those ranging along the coasts of Manitoba and Ontario represent fairly distinct subpopulations. The principal aim of this research, therefore, was to compare the food habits of these supposed subpopulations and to interpret the nature of any differences in their effects on the subpopulations.

Quantitative and qualitative analyses were made of 233 scats collected from islands in James Bay and 212 scats gathered on the coast of Hudson Bay between Cape Churchill, Manitoba and Cape Henrietta Maria, Ontario.

Comparison of results of scat analyses for the two regions shows considerable differences in kinds of foods consumed. Birds (primarily Anatidae) are overwhelmingly the most commonly used summer and autumn food of bears in James Bay, while grasses and marine algae are most often eaten by bears frequenting the mainland. Other items

found in lesser quantities include berries, eelgrass, leaves and stems of broad-leaved shrubs and herbs, lichens, mosses, mushrooms, sedges, seals, hair and claws of polar bears, muskrats, voles, mussels and sea urchins.

The diet of polar bears in James Bay, therefore, appears high in protein and fats compared to that of mainland bears which is primarily of carbohydrates. On the basis of this information one would expect that the diet of bears from James Bay better prepares them for winter than that of the mainland subpopulation. However, evidence suggests that polar bears in both regions are generally in good physical condition. Both subpopulations appear to be maintaining their numbers and are, perhaps, increasing. Therefore, it is possible that summer and autumn diet may not be an important factor in limiting numbers of polar bears.

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Introduction

Research on summer and autumn food habits of island and mainland populations of polar bears (*Ursus maritimus* Phipps) began in 1968 in conjunction with population studies undertaken on this species by the Canadian Wildlife Service. Data were gathered between July 1 and November 1 in 1968 and 1969.

Historically, polar bears were land-bound in large numbers during summer in Labrador (Copland, 1968), Newfoundland, Iceland, the coasts of Hudson and James bays, and on islands throughout the Bering Sea. In recent years, however, large numbers of bears become land-bound during summer, for periods ranging from three to five months (mid-July to mid-December), depending upon latitude and annual fluctuations in climate, only in the James and Hudson bay basins. This situation presented an unique opportunity to gather data on the food habits of polar bears living at least part of the year under quite different conditions from those in more northern areas. Also, because this region is now the most southerly extension of the range of this species the data promised to be useful for later comparison with the food habits and the effect of presumably different food habits on growth rates, reproductive rates, and behaviour of polar bears in the High Arctic.

Data on tagged bears suggested that the bears inhabiting islands in the James Bay region comprise a subpopulation which is at least partially distinct from bears living along the southwest side of Hudson Bay. My hypothesis was that if separate subpopulations existed, differences in food habits and feeding behaviour may exist. The principal aim of this research, therefore, was to compare the food habits of these supposed subpopulations and to interpret the nature of any differences in their effects on the subpopulations. Ultimately, it is hoped that this research will contribute to the formation of domestic and international management policies.

Quantitative and qualitative data on the food habits of polar bears are scarce. Lønø (1970) analyzed the stomach contents of 172 bears killed by hunters in pack ice near Svalbard (Spitzbergen) during summer and winter, 1961 to 1967. Tsalkin (1936) examined 145 stomach samples collected on the Franz Josef Archipelago, U.S.S.R. However, both these studies dealt with bears in the High Arctic. Nothing has been recorded on the food habits of polar bears in Hudson and James bays.

The general approach to this study was through collection and analysis of scats. Two hundred and thirty-three scats were analyzed from the James Bay subpopulation

and 212 from bears on the coasts of Manitoba and Ontario. Because polar bears were protected in Manitoba and Ontario during this study, stomach samples were not available, but some observations of bears feeding supplement the analysis of scats.

Description of Study Areas

My study areas extend 1150 kilometers from central James Bay to Cape Churchill, Manitoba. On the mainland, data were gathered in the vicinities of Cape Henrietta Maria, Ontario; West Pen Island, Ontario; and Cape Churchill, Manitoba (Figure 1). In James Bay all data were collected from South and North Twin islands, and associated smaller islands, hereafter referred to as the James Bay collection.

Marine clay and beach sand deposits overlying Paleozoic sedimentary bedrock extend from the west side of James Bay and southwest side of Hudson Bay north to Cape Churchill. The topography is flat and drainage poor throughout (Rowe, 1959).

Though southern in latitude compared with polar bear habitat elsewhere, the area is strongly influenced by both arctic and maritime climates. The vegetation reflects exposure to, or protection from winds, instability of soils due to permafrost, and low air temperature (Rowe, 1959). Hustich (1957) has described the immediate areas around Cape Henrietta Maria and Cape Churchill as arctic barrens. Most of the intervening coastline between the two sites belongs to a very narrow hemi-arctic region (Sjörs, 1963).

Figure 1. Map of study area in Hudson Bay and James Bay showing major sites of collections.


90°
80°
N.W.T.
CAPE CHURCHILL
60°
HUDSON BAY
WEST PEN ISLAND
MANITOBA
CAPE HENRIETTA MARIA
55°
JAMES BAY
ONTARIO
NORTH TWIN ISLAND
300 Km.
QUEBEC

It has been termed "la zone de transition" (toward the arctic) (Dutilly, et al., 1954). West Pen Island falls within this classification. For the most part, treeline is within 2 to 20 km of the coast in the hemi-arctic region. At both Cape Churchill and Cape Henrietta Maria, however, the northern limit of conifers lies 35 to 50 km to the southwest. Coombs (1954) called this the "coastal zone" and distinguished it physiographically from inland subdivisions of the Hudson Bay Lowlands.

The southwest coastline of Hudson Bay is similar throughout in many ways. The two "Capes" feature low ridges of sand and alluvium with adjacent low marshy marine flats. Sand dunes, partially stabilized by plants such as *Elymus arenarius*, are prominent on the perimeter of West Pen Island, which is approximately 90 km^2 in area. Again, low marshy areas are nearby. West Pen is an island only in the strictest sense -- at high tide it is separated from the mainland by a channel 3-6 m wide. Therefore, for purposes of this study it was considered part of the mainland.

North Twin Island is typical of the islands used by polar bears in James Bay. It falls somewhere between the categories of arctic barrens and hemi-arctic woodland tundra region. Coombs included it in the coastal

physiographic subdivision of the Hudson Bay Lowlands. The island comes under strong arctic influence and small groves of conifers are found only sparsely. The island has an area of 200 km^2. Vegetation is mainly of tundra species. The flat relief of the island is broken by a ridge rising to a maximum of 81 m above sea level and extending 1-3 km inland along the east side of the island.

Methods

I. Capture and marking

To facilitate studies on the validity of discrete subpopulations in Hudson and James bays, polar bears were captured and marked by Canadian Wildlife Service personnel using techniques described by Jonkel (1967a, 1970a).

II. Classification of sex and age groups

Classification of sex and age groups of polar bears was possible by means of aerial surveys. Helicopters, which afforded close inspection of individuals were used mainly.

III. Estimates of abundance of food items

Qualitative estimates of abundance of certain species of plants and animals used by polar bears were made on the basis of personal observations, expert opinion of others, and occasionally, published estimates. The latter, however, are scarce for the Hudson and James bay region.

IV. Collection of scats

During the summers and autumns of 1968 and 1969 scats of polar bears were collected on islands in James Bay and

along the Hudson Bay coast of Manitoba and Ontario. For purposes of this study, bears frequenting the islands of James Bay were considered island oriented, while bears at the other three sites represent the mainland subpopulation.

The areas systematically searched on the mainland each measured 2-5 km^2 though scats found while en route to and from campsites were also collected. In James Bay scats were recovered from over the entire islands, but the most thorough searches were conducted along a 25 km^2 strip on the east side of North Twin Island.

All scats found were collected regardless of age or condition. No attempt was made to determine the age of scats since the rate of decomposition appeared to depend upon the content, dryness of substrate, and exposure of the site to wind and sun. Some samples from dry areas may have been several years old.

Entire scats were collected in all cases. Care was used to ensure that a minimum of extraneous material (lichens, leaves, sticks, gravel, sand) adhered to them. Some contamination was impossible to avoid, however.

V. Preservation of scats

Extremely moist droppings were collected in plastic

bags and frozen. The remainder were stored in paper bags. The latter were later air-dried in the laboratory or outdoors when weather permitted. When dry, samples were labelled and stored in paper bags until analyzed.

VI. Scat analysis

Dried scats were soaked overnight in water prior to analysis. The softened material was washed through a series of screens (Canadian Standard Sieve Series #7, 10, and 20). The screenings were immersed in water in 9" x 14" white enamel trays. With the aid of bright illumination near the water surface, the material was examined macroscopically and specimens of all recognizable items were removed. Parts such as flowers, seed pods, spicules, and leaves, in the case of plants, and teeth, bones, or feathers, in the case of mammals and birds, were selected to facilitate identification. A binocular microscope was used when necessary. The majority of scats were too large to handle in one screening so this process was repeated until the entire scat had been examined. All items selected for identification were stored in vials, either dry (e.g. feathers and bones) or in 10% formalin (e.g. marine algae and flowers) until identified.

A volumetric analysis similar to the methods of

Clark (1957) for scats of Kodiak bears (U. arctos) and of Tisch (1961) for scats of black bears (U. americanus) was used.

As a scat was analyzed, the volume of each component was estimated and placed in one of six volumetric categories: 100-95%; 95-75%; 75-50%; 50-25%; 25-5%; and 5%-trace (a weakness in this method is recognized, as the relative amounts of digested food items found in scats are not always indicative of the amounts ingested by the animal). Occurrences and volumetric data were recorded on prepared data sheets. A volume index was calculated for each food item. This was derived from an average percent volume based on mid-points for each volumetric category.

Final identifications of most items were confirmed by comparison with specimens collected by me or with the assistance of staff at the National Museum of Natural Sciences, Ottawa, Canada; often by comparison with collections housed at the museum.

Identification to species was attempted for all items. At times it was not possible to identify items more accurately than to genus or family. Grasses were particularly difficult to identify if only vegetative characters were available. When two or more species of grass were present in the same sample it was impossible to estimate their

relative volumes. In such cases identification was recorded only as Gramineae. *Elymus arenarius* was the only grass distinct enough to be readily separable from others on the basis of morphology of the culm and leaf alone. Berries were readily identified by comparing seeds with samples from reference collections. Leaves and stems of shrubs and herbs were identified by comparison with herbarium specimens. Keys to the vascular plants of the arctic by Porsild (1964) and Hultén (1968) were helpful. Marine algae were identified to genus, and sometimes to species, by gross morphology of thalli and stipites. Often algae were altered very little by digestion and were easily identified.

In scats containing the remains of birds, I selected feathers of as many different types as possible and from these, I was usually able to make a positive identification. Toenails, feet, and the nails from bills of Anatidae were helpful. Ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) were identified by the morphology of vibrissae, toenails, and hair. Teeth were recovered from most scats in which small mammals occurred and these were identified by means of a key to skull characteristics (Glass, 1951). Invertebrates were identified by comparison of hard parts such as exoskeletons with collected specimens.

Scats collected in 1968 and 1969 are combined because of the difficulty in aging scats beyond the fresh stage.

The results were analyzed statistically by means of 2 x 2 Chi-square tests for goodness of fit. If sample sizes were large a G-test with Yates correction was used; Fisher's exact test was used where sample sizes were small (Sokal and Rohlf, 1969).

The results of analyses of 48 scats collected outside the study areas are presented in Appendices I to VI.

Results and Discussion

The data are presented in several sections. Sections I and II deal with the discreteness of subpopulations and the segregation of polar bears by sex and age on the mainland. The numbers of females with young relative to numbers of other polar bears on North Twin Island are also presented. Results of analyses of scats collected on island and mainland areas are presented in tabular form in Sections III and IV. Specific food items from the two regions are compared and discussed in Section V. The location of collections and total number of scats collected in each area are presented in Table 1.

I. Subpopulations

Data on movements gathered from marked bears in the period 1966-70 are presented in Table 2. Of 158 bears tagged on the mainland none have been recaptured or resighted in James Bay. Only one bear out of 59 marked in James Bay has been sighted on the mainland. This bear was observed near Cape Henrietta Maria, 240 km from the original site of capture near North Twin Island. Two others were shot by Eskimos on Belcher Islands, 160 km north of James Bay. It appears, therefore, that mixing

Table 1. Dates and numbers of scats collected at four sites in Hudson Bay and James Bay in 1968-69.

Subpopulation		Number Collected	Period
Islands			
James Bay	1968	179	April 13, July 14-25
	1969	54	July 27-September 14
	Total	233	
Mainland			
Cape Henrietta Maria	1968	16	September 13-19
	1969	32	June 23, September 5
West Pen Island	1968	3	August 23-26
	1969	75	August 18-21
Cape Churchill	1968	--	
	1969	86	August 7, October 15
	Total	212	

Table 2. Recoveries of polar bears tagged in James Bay and along the coast of Manitoba and Ontario (The figures below represent a minimum time lapse of three months between capture and recovery).

Location	Bears Tagged (to 1970)	Numbers Killed		Numbers of Recaptures or Observations		Total Recoveries	
		same area	else-where	same area	elsewhere	same area	else-where
James Bay	59	7	2	14	1	21	3
Coast of Manitoba and Ontario	158	17	2	56	0	73	2

between the two subpopulations is uncommon.

II. Sex and age classes of polar bears on the coasts of Manitoba and Ontario, and in James Bay

Aerial surveys along the mainland beaches in summer show a large number of adult males compared to females and sub-adults (Table 3). Adult males tend to concentrate on the coast, particularly on promontories of land like Cape Churchill, but also on minor capes and sand spits. As freeze-up approaches in autumn there is an even greater concentration of adult males at Cape Churchill (Table 4). The majority of females with cubs are also found close to the coast, but in areas between the groups of males. Other bears of various ages and sexes are spread inland for up to 200 km. Most scats from the mainland were collected not more than one kilometer from high tide mark in areas favoured by adult males. Only these areas contained sufficient scats to warrant intensive searching. Data from the mainland, therefore, likely reflect food habits of bears which frequent the beaches, especially adult males. Polar bears spending the summer farther inland may have a different diet but no efficient method of collecting sufficient numbers of the widely scattered scats has been devised.

Table 3. Sex and age classes of polar bears observed during late summer in the vicinities of three collection sites on the coasts of Manitoba and Ontario.

Region	Year	Dates of Survey	Families Females	Families Young	Adult females without young	Adult males	Unclassified*
Vicinity of Cape Churchill, Manitoba	1969	Aug. 7-10	2	4	1	15	10
	1970	Aug. 21-28	1	1	-	21	9
Vicinity of Pen Islands, Ontario	1969	Aug. 17-22	7	12	3	29	17
	1970	Sept. 5-6	6	11	-	43	7
Vicinity of Cape Henrietta Maria, Ontario	1969	Sept. 5	2	3	-	17	4
	1970	Sept. 9-10	3	4	-	37	14
Totals	1969	Aug. 7-Sept. 5	11	19	4	61	31
	1970	Aug. 21-Sept. 10	10	16	-	101	30

*Includes sub-adults after weaning and probably some adult females without young which are sometimes difficult to distinguish from sub-adult males.

Table 4. Sex and age classes of polar bears observed during mid-autumn in the vicinity of Cape Churchill.

Year	Dates of Survey	Families Females	Families Young	Adult females without young	Adult males	Unclassified
1969	Oct. 23	-	-	1	44	11
1970	Nov. 5	4	7	-	91	20

Aerial surveys of North Twin Island in James Bay in 1968 and 1970 show a heterogeneous population of polar bears (Table 5). Females with young and other bears, including adult males, occupied the island in close proximity to each other, though this may not be the case every year. A comparable survey was not made in 1969, but B. Knudsen (pers. comm.) did not see any family groups on the island from mid-July to mid-September. This may have been caused by an unusually cool season during which broken pack ice was adjacent to the island throughout the summer. Scats collected in James Bay probably are more representative of different age and sex classes than from those collected on the mainland. Whether or not this difference in sex and age classes of bears in the two areas accounts for differences in food habits is unknown, but any effect is probably not great.

III. Analyses of scats from James Bay

The results of analyses of 233 scats collected in James Bay are presented in Table 6. Avian remains clearly dominated the sample, both in frequency of occurrence (69.1%) and volumetrically (57.5%). Oldsquaw ducks (*Clangula hyemalis*) represented over half the total volume of birds. Invertebrates were found in 14.6% of the samples

Table 5. Sex and age classes of polar bears on North Twin Island, James Bay.

Date of Survey	Families Females/Young		Unclassified*
September 30, 1968	10	19	32
September 15, 1970	10	15	14

*Includes adult males, sub-adults after weaning, and adult females without young.

Table 6. Items identified in 233 polar bear scats collected on North Twin and associated islands, James Bay, 1968-69. (Bracketed letters after the names of items represent qualitative estimates of availability. A=abundant; C=common; R=rare; U=unknown)

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
ANIMAL REMAINS								
Aves								
Anatidae:								
Clangula hyemalis (A)	64	6	4	1	5	-	34.3	31.3
Somateria spp. (C)	11	3	3	2	1	-	8.6	7.1
Branta canadensis (A)	4	3	-	1	-	1	3.9	3.0
Oidemia nigra (C)	2	-	-	-	-	-	0.9	0.9
Mergus spp. (C)	2	-	-	-	-	-	0.9	0.9
Laridae:								
Larus argentatus (A)	2	1	-	-	-	-	1.3	1.2
Gaviidae:								
Gavia spp. (C)	2	-	-	-	-	-	0.9	0.9
Unidentified Aves:	17	5	6	5	6	11	21.5	12.6
Egg shells:	-	-	-	1	3	7	4.7	0.4
Total Avian Remains	113	11	11	8	6	12	69.1	57.5

Table 6. continued ii.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
ANIMAL REMAINS (continued)								
Mammalia								
Phocidae: (ringed and bearded seals) (A)	2	1	1	6	3	9	9.4	2.8
Ursidae:								
Ursus maritimus (A)	2	-	-	-	3	19	10.3	1.3
Total mammalian remains	4	1	1	6	6	25	18.9	4.1
Invertebrata (marine)								
Mytilus edulis (A)	2	-	2	1	3	16	10.3	1.9
Strongylocentrotus droehbachiensis (C)	-	1	1	1	2	10	6.4	1.1
Total marine invertebrate remains	2	2	3	-	4	23	14.6	2.9
Insecta	-	-	-	-	-	1	0.4	-
PLANT REMAINS								
Marine algae								
Phaeophyta:								
Laminaria spp. (A)	-	-	2	3	6	11	9.4	1.6
Fucus spp. (A)	-	2	2	2	8	11	10.7	2.3

Table 6. continued iii.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Marine algae (continued)								
Phaeophyta: (continued)								
Desmarestia aculeata (U)	-	-	-	-	-	2	0.9	-
Sphacelaria spp. (U)	-	-	-	-	-	2	0.9	-
Alaria spp. (U)	-	-	-	-	1	-	0.4	0.1
Rhodophyta:								
Neodilsea integra (R)	-	-	-	-	-	1	0.4	-
Chlorophyta:								
Urospora mirabilis (U)	-	1	-	-	1	-	0.9	0.4
Chaetomorpha spp. (U)	-	-	-	-	-	1	0.4	-
Unidentified Chlorophyta	-	-	-	-	1	-	0.4	0.1
Unclassified marine algae	-	-	-	-	1	2	1.3	0.1
Total marine algae	5	1	2	4	8	13	14.2	4.4
Gramineae:								
Elymus arenarius (A)	4	3	4	2	1	3	7.3	4.4
Other Gramineae	7	4	6	5	10	13	19.3	7.8
Total Gramineae	11	7	10	7	11	16	26.7	12.1
Juncaceae (A)	-	-	-	-	-	5	2.1	0.1

Table 6. continued iv.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Cyperaceae (A)	1	-	-	2	3	6	5.2	1.0
Berries and other fruits								
Empetrum nigrum (A)	-	28	7	6	8	29	33.5	14.2
Juniperus communis (C)	-	-	1	1	5	7	6.0	0.8
Vaccinium Vitis-idaea (C)	-	-	-	-	2	3	2.1	0.2
Vaccinium uliginosum (C)	-	-	-	-	-	5	2.1	0.1
Arctostaphylos alpina (C)	-	-	-	-	-	1	0.4	-
Pyrola grandiflora (C)	-	-	-	-	-	1	0.4	-
Unidentified seeds	-	-	-	-	-	3	1.3	-
Total berries and other fruits	-	28	8	7	12	36	39.1	15.1
Leaves and stems of shrubs and broad-leaved herbs								
Salix spp. (A)	-	-	-	-	1	98	42.5	1.1
Empetrum nigrum (A)	-	-	-	-	28	47	32.2	2.4
Betula grandulosa (A)	-	-	-	1	-	42	18.5	0.6
Vaccinium uliginosum (C)	-	-	-	-	-	56	24.0	0.6
Vaccinium Vitis-idaea (C)	-	-	-	-	-	30	12.9	0.3
Juniperus communis (C)	-	-	-	-	1	14	6.4	0.2
Dryas integrifolia (A)	-	-	-	-	-	17	7.3	0.2
Saxifraga tricuspidata (C)	-	-	-	-	-	1	0.4	-

Table 6. continued v.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Leaves and stems of shrubs and broad-leaved herbs (continued)								
Unidentified	-	-	-	-	-	26	11.2	0.3
Total leaves and stems of shrubs and broad-leaved herbs	-	-	-	1	29	127	67.4	3.5
Mosses (A)	2	-	2	2	5	45	24.0	2.6
Lichens (A)	-	-	-	-	-	42	18.0	0.5
Mushrooms (C)	-	-	-	1	5	13	8.2	0.6
Lycopodiaceae:								
Lycopodium spp. (C)	-	-	-	-	3	4	3.0	0.2
Equisetaceae:								
Equisetum spp. (C)	-	-	-	-	-	2	0.9	-
MISCELLANEOUS ITEMS								
Sand	-	1	1	2	1	-	2.1	1.0
Wood chips	-	-	-	-	-	7	3.0	0.1
Bone fragments	-	-	-	-	-	1	0.4	-

Table 6. continued vi.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
MISCELLANEOUS ITEMS (continued)								
Lead shot #2	-	-	-	-	-	1	0.4	-
Plastic ribbon	-	-	-	-	-	1	0.4	-
Pebbles	-	-	-	-	-	1	0.4	-
Total miscellaneous items	-	1	1	2	1	11	4.7	1.2

but had a volume index of only 2.9%. Similarly, seals occurred in 9.4% of the feces and their remains formed 2.8% by volume. Remains of polar bears were identified in 10.3% of the sample.

Vegetation was secondary to animal remains but still represented a little over one-third of total volume. In terms of frequency of occurrence, leaves and stems of shrubs and broad-leaved herbs were identified in 67.4% of the scats. However, since they usually occurred in trace amounts, their volume index was only 3.5%. Berries and other fruits had the highest volume index, 15.2%, and a frequency index of 39.1%. Next were grasses, with values of 12.1% and 26.7% for volume and frequency, respectively. Marine algae were found in 14.2% of the scats, making up 4.4% of the volume. Brown algae (Phaeophyta) were more common than red (Rhodophyta) or green (Chlorophyta) algae. Mosses were fairly common in terms of frequency (24.0%), as were lichens (18.0%) but even when combined they made up only 3.0% of the volume. Mushrooms, rushes, sedges, club moss, horsetail and assorted miscellaneous items were found in lesser amounts.

IV. Analyses of scats from the mainland

Results of analyses of 212 scats collected along the

coast of Manitoba and Ontario are presented in Table 7. In contrast to James Bay scats, animal remains placed second to vegetation on the mainland both in frequency and volume. Avian remains occurred in 26.4% of the sample. However, most of the occurrences were in trace amounts so the volume index was only 1.9%. Likewise marine invertebrates were commonly found (25.5%) but were relatively insignificant volumetrically (0.9%). Seals occurred at the same frequency (9.4%) and twice the volume (6%) in mainland scats compared with scats from James Bay. Small mammals were found in 20.3% of mainland scats with a volume index of 4.3%. The frequency of occurrence of polar bear remains was 29.7% but most scats contained only trace amounts. Insects and fish were represented in small amounts both by frequency and volume.

Two plant types were well represented; grasses were identified in 80.2% of the samples and made up 42.8% of the total by volume and combined species of marine algae registered 70.8% by frequency and 40.6% by volume. Brown algae were most abundant in scats, but red algae were also common. Traces of leaves and stems of shrubs and broad-leaved herbs were identified in 21.7% of the samples. Frequency and volume for mosses were 12.3% and 2.2%, respectively. Berries, lichens, mushrooms, rushes, eel

Table 7. Items identified in 212 polar bear scats collected on the coastal mainland of Manitoba and Ontario, 1968-1969. (Bracketed letters after the names of items represent qualitative estimates of availability. A=abundant; C=common; R=rare; U=unknown.)

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
ANIMAL REMAINS								
Aves								
Anatidae:								
Clangula hyemalis (C)	-	-	1	-	1	1	1.4	0.4
Passeriformes	-	-	-	-	-	1	0.5	-
Unidentified Aves	2	-	-	-	-	50	24.5	1.5
Total avian remains	2	-	1	-	1	52	26.4	1.9
Mammalia								
Phocidae: (ringed and bearded seals) (A)	7	3	3	2	2	3	9.4	6.0
Ursidae:								
Ursus maritimus (A)	2	-	-	-	3	58	29.7	1.9
Cricetidae:								
Ondatra zibethicus (C)	1	2	3	-	1	1	3.8	2.3
Microtus pennsylvanicus (C)	-	-	2	2	11	19	16.0	2.0
Unidentified	-	-	-	-	-	4	1.9	-
Total mammalian remains	10	5	8	4	17	78	57.5	10.9

Table 7. continued ii.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Fre-quency Index (%)	Volume Index(%)
ANIMAL REMAINS (continued)								
Invertebrata (marine)								
Mytilus edulis (A)	-	-	-	-	1	14	7.1	0.2
Ascidiaceae (C)	-	-	-	-	3	31	16.0	0.6
Other miscellaneous invertebrates	-	-	-	-	-	20	9.4	0.2
Total marine invertebrate remains	-	-	-	-	4	50	25.5	0.9
Insecta (C)	-	-	-	-	1	7	3.8	0.2
Pisces (R)	-	-	-	-	-	1	0.5	-
PLANT REMAINS								
Marine algae								
Phaeophyta:								
Fucus spp. (A)	3	12	13	13	30	59	61.3	15.5
Laminaria spp. (A)	3	3	7	7	24	26	33.0	8.1
Sphacelaria spp. (C)	-	-	-	6	14	44	30.2	2.6
Desmarestia aculeata (C)	-	-	-	1	5	12	8.5	0.7
Agarum cibrosum (R)	-	-	-	-	-	1	0.5	-
Rhodophyta:								
Neodilsea integra (C)	11	15	6	2	6	2	19.8	14.0
Rhodymenia palmata (C)	-	2	2	3	2	5	6.6	2.2

Table 7. continued iii.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Marine algae (continued)								
Rhodophyta: (continued)								
Ahnfeltia spp. (U)	-	-	-	-	-	3	1.4	-
Rhodomela lycopodioides (U)	-	-	-	-	-	1	0.5	-
Total marine algae	43	26	16	17	18	30	70.8	40.6
Gramineae:								
Elymus arenarius (A)	14	19	10	10	18	16	41.0	20.8
Other Gramineae	33	5	6	7	16	16	39.2	22.1
Total Gramineae	47	24	16	17	34	32	80.2	42.8
Juncaceae:								
Juncus balticus (A)	1	1	-	-	2	1	2.4	1.0
Potamogetonaceae:								
Zostera marina (A)	1	-	-	-	1	15	8.0	0.7
Cyperaceae:								
Carex saxitalis (A)	-	-	-	1	-	-	0.5	0.2
Unidentified	-	-	-	-	1	1	0.9	0.1

Table 7. continued iv.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Total Cyperaceae	-	-	-	1	1	1	1.4	0.3
Berries and other fruits								
<u>Empetrum</u> <u>nigrum</u> (C)	-	1	-	1	-	2	1.9	0.6
<u>Oxytropus</u> <u>podocarpa</u> (U)	-	-	-	-	-	1	0.5	-
Unidentified	-	-	-	-	-	1	0.5	-
Total berries and other fruits	-	1	-	1	-	4	2.8	0.6
Leaves and stems of shrubs and broad-leaved herbs								
<u>Salix</u> spp. (A)	-	-	-	-	1	18	9.0	0.3
<u>Saxifraga</u> <u>tricuspidata</u> (C)	-	-	-	-	2	5	3.3	0.2
<u>Empetrum</u> <u>nigrum</u> (C)	-	-	-	-	1	4	2.4	0.1
<u>Arenaria</u> <u>peploides</u> (R)	-	-	-	-	-	2	0.9	-
<u>Arctostaphylos</u> spp. (C)	-	-	-	-	-	2	0.9	-
<u>Astragalus</u> spp. (C)	-	-	-	-	-	1	0.5	-
<u>Dryas</u> <u>integrifolia</u> (A)	-	-	-	-	-	1	0.5	-
<u>Euphrasia</u> <u>arctica</u> (C)	-	-	-	-	-	1	0.5	-
<u>Parnassia</u> <u>parviflora</u> (C)	-	-	-	-	-	1	0.5	-
<u>Vaccinium</u> <u>uliginosum</u> (C)	-	-	-	-	-	1	0.5	-
Unidentified	-	-	-	-	-	17	8.0	0.2

Table 7. continued v.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
PLANT REMAINS (continued)								
Total leaves and stems of shrubs and broad-leaved herbs	-	-	-	-	4	42	21.7	0.8
Mosses (A)	-	2	1	4	2	17	12.3	2.2
Lichens (A)	-	-	-	-	1	5	2.8	0.8
Mushrooms (C)	-	-	-	-	1	3	1.9	0.1
MISCELLANEOUS ITEMS								
Wood chips	-	-	1	2	2	21	12.3	1.1
Styrofoam	-	1	-	1	1	3	2.8	0.7
Sand	-	-	-	1	1	-	0.9	0.3
Cardboard	-	1	-	-	-	-	0.5	0.4
Bone fragments	-	-	-	-	1	10	5.2	0.2
Pebbles	-	-	-	-	-	1	0.5	-
Tire rubber	-	-	-	-	-	1	0.5	-
Total miscellaneous items	-	2	1	4	5	36	17.0	2.6

grass, sedges, and miscellaneous material were only occasionally represented.

V. Comparison of specific food items between areas

i. Animal remains

a. Aves

A marked difference between island and mainland subpopulations was evident in the frequency of occurrence of birds in scats from the two areas (Figure 2). This difference was even more obvious when considered in terms of volume (Figure 3). In the James Bay sample, of 161 scats in which remains of birds were noted, birds were in the largest volumetric category in 113. In contrast to this, only two of 56 scats in which birds occurred from the mainland contained birds in the greatest category. This is a considerable difference statistically and helps to explain the large numerical difference in the volume index values.

In the James Bay samples, oldsquaw ducks were most often found. Eiders (_Somateria_ spp.) were a distant second, followed by Canada geese (_Branta canadensis_), common scoters (_Oidemia nigra_), mergansers (_Mergus_ spp.), herring gulls* (_Larus argentatus_), and loons (_Gavia_ spp.)

*In 1968 a leg band was recovered from a scat in which only herring gull remains were identified. Positive identification was supplied by the U.S. Fish and Wildlife Service. The bird was banded as a fledgling at a nesting ground in Michigan in 1965.

Figure 2. Frequencies of occurrence of four foods for island and mainland subpopulations of polar bears.

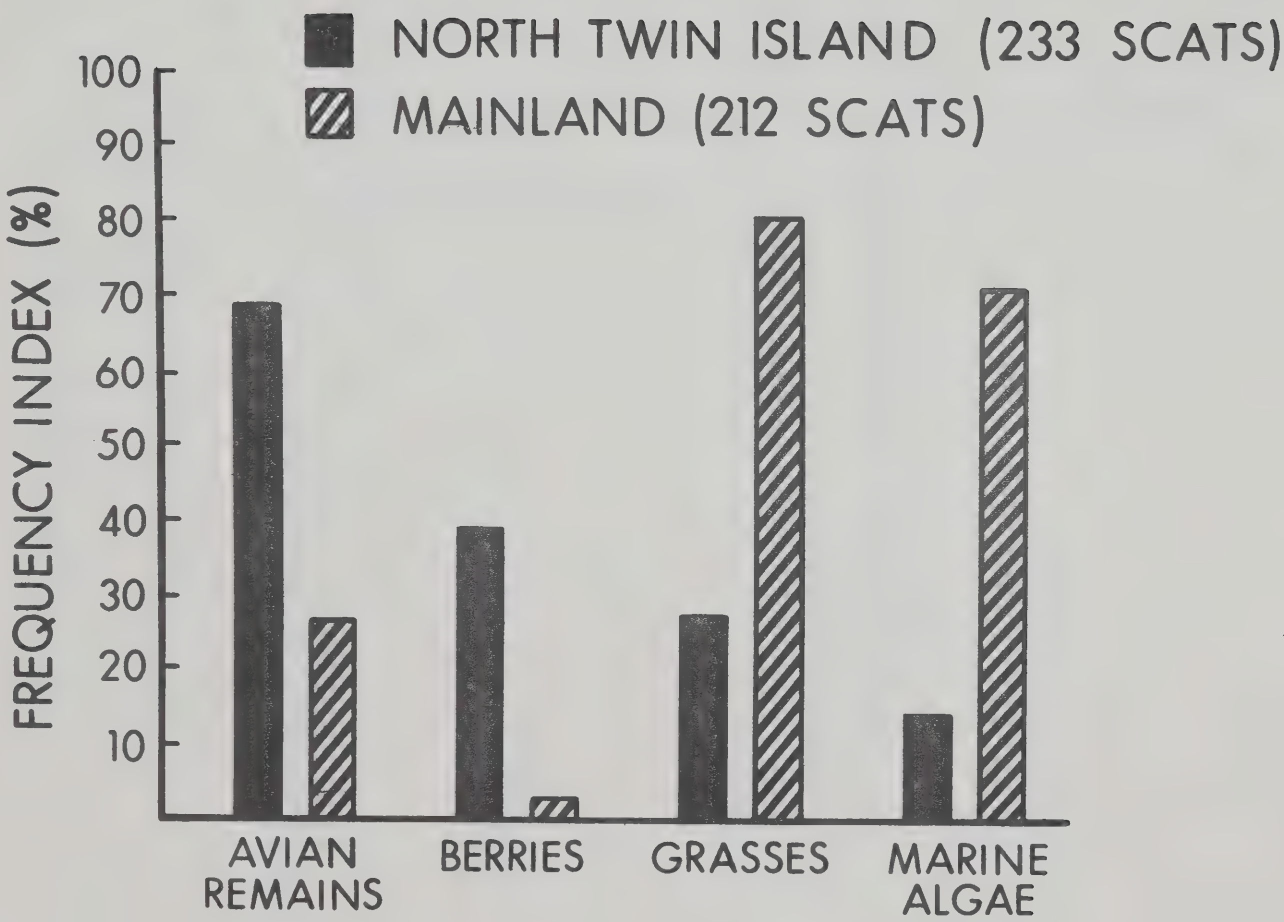
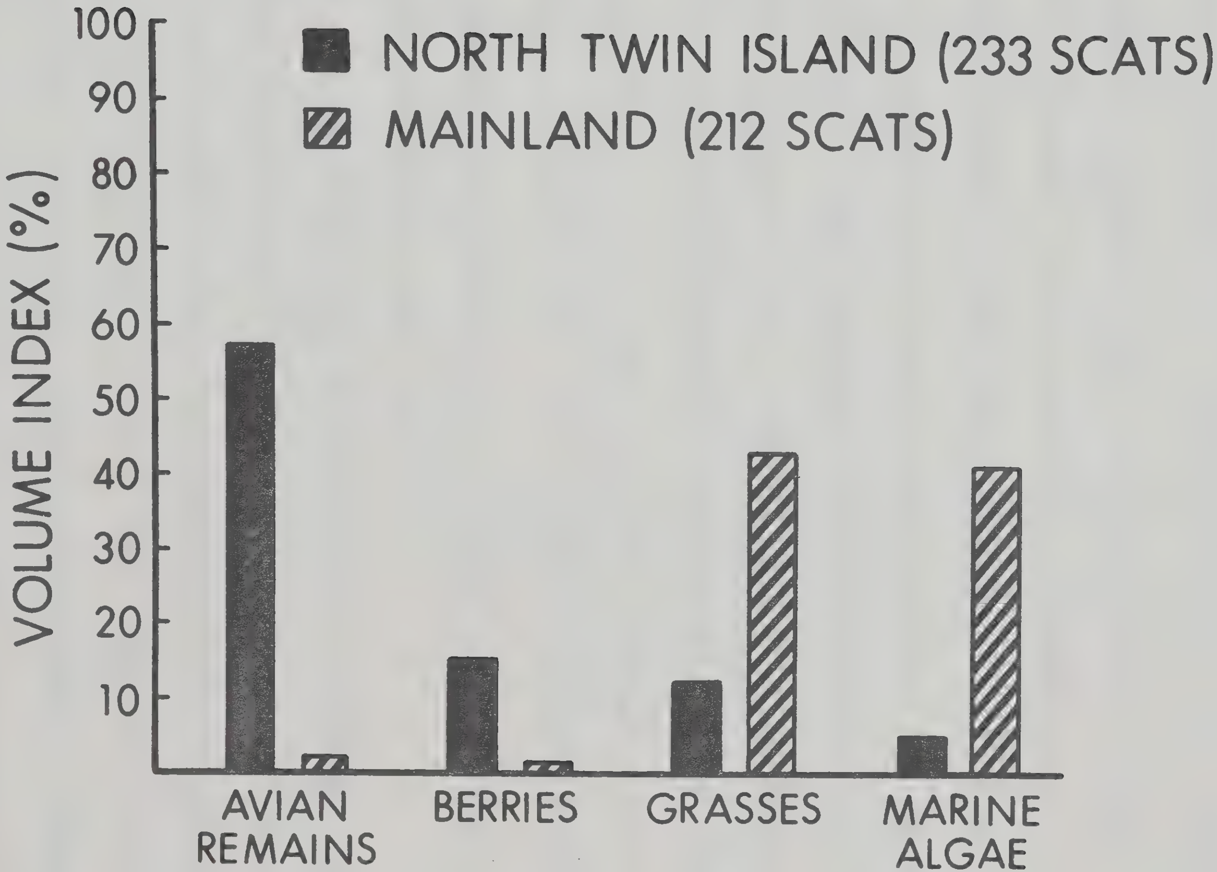

NORTH TWIN ISLAND (233 SCATS)
MAINLAND (212 SCATS)
FREQUENCY INDEX (%)
100
90
80
70
60
50
40
30
20
10
AVIAN REMAINS
BERRIES
GRASSES
MARINE ALGAE

Figure 3. Volume indices of four foods for island and mainland subpopulations of polar bears.


NORTH TWIN ISLAND (233 SCATS)
MAINLAND (212 SCATS)
VOLUME INDEX (%)
100
90
80
70
60
50
40
30
20
10
AVIAN REMAINS
BERRIES
GRASSES
MARINE ALGAE

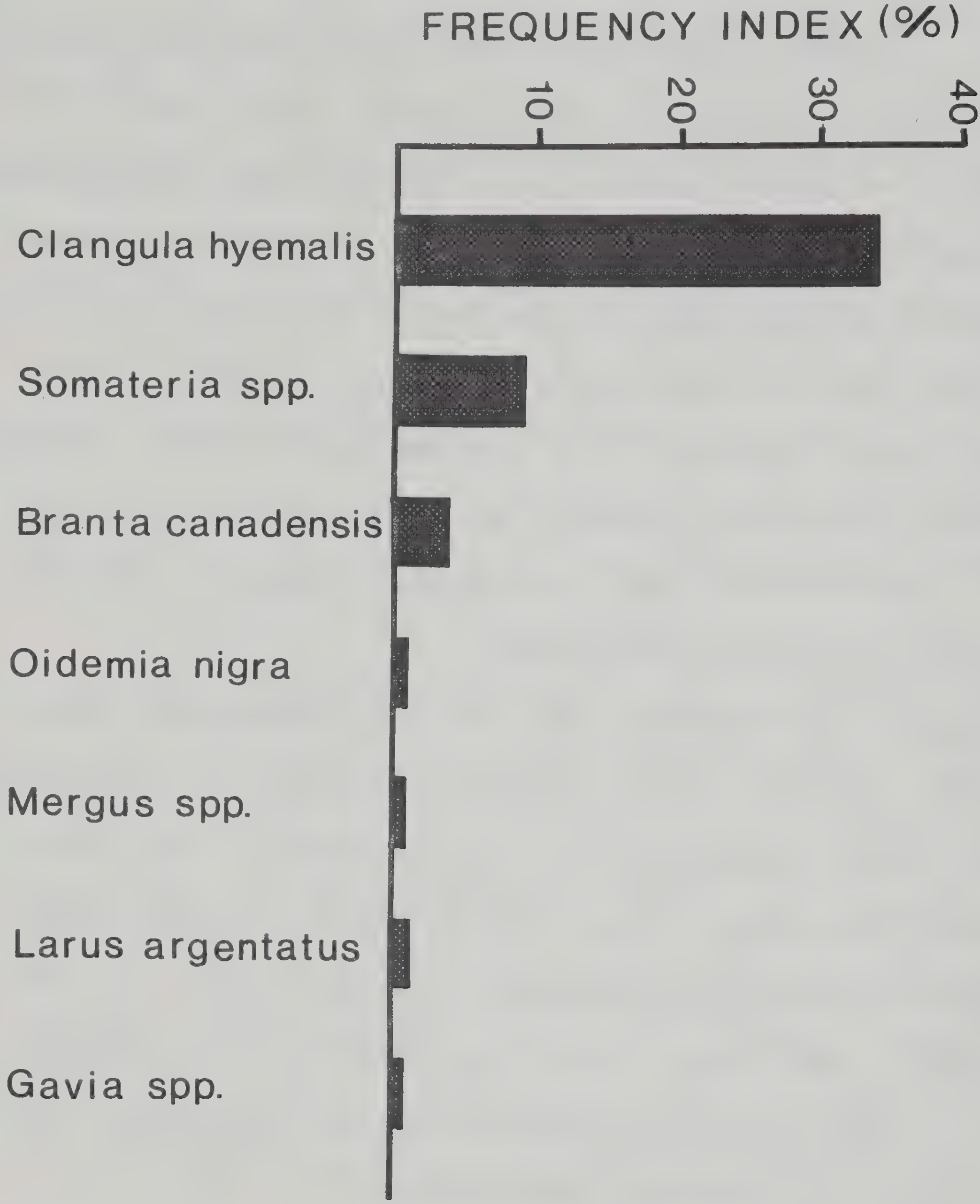
in that order (Figure 4). Egg shells occurred in 4.7% of the sample, primarily in trace amounts.

It may be of interest to look at the availability of the species most widely consumed by the bears. Oldsquaws are abundant in summer on the sea around North Twin Island. It is common to observe rafts of this species offshore in which birds number in the hundreds. Oldsquaws were only occasionally seen on shore (at the edge of the water) and no nests or evidence of nesting was found on the island in July, 1968. Only two broods were observed in the summer of 1969 (B. Knudsen, pers. comm.). However, nesting may occur on the nearby islands of South Twin, Walter, Spencer, and Grey Goose, all of which are within 35 km of North Twin Island. Eiders were also common on the sea though not as numerous as oldsquaws. A few nests were observed on North Twin Island each year.

An estimated 200-300 breeding pairs of Canada geese nest annually on North Twin Island (B. Knudsen, pers. comm.). Polar bears usually appear in concentrations on the island in July, at which time the geese have completed incubation, but when many adults and young are flightless. Through most of July and August flightless geese are abundant over the entire island.

Because the majority of birds in the mainland sample

Figure 4. Frequency indices of seven genera of birds found in scats collected in James Bay. (The frequencies of *Oidemia*, *Mergus*, *Larus*, and *Gavia* are not significantly different from one another. The frequencies of *Clangula*, *Somateria*, and *Branta* are significantly different from each other and from the others.)



FREQUENCY INDEX (%)
10
20
30
40
Clangula hyemalis
Somateria spp.
Branta canadensis
Oidemia nigra
Mergus spp.
Larus argentatus
Gavia spp.

occurred in trace amounts it was possible to identify only a few to the species level. Oldsquaw were noted in three scats and an unidentified passerine in one. There was no evidence that eggs had been consumed.

Heavy feeding on birds has not been documented elsewhere. Lønø (1957) stated that polar bears in the Spitzbergen region will take adult sea-birds, young, and eggs when the occasion arises, mainly during breeding season. He did not regard birds as a major source of food, however. Pedersen (1962) and Harington (1965) also mentioned birds as an occasional food source in Spitzbergen and the Canadian arctic, respectively.

Data from my study suggest that raiding of nests by polar bears is not common. This may be because the bears are on the ice pack at the peak periods of hatch. Loughrey (1956) reports a polar bear which walked through a colony of nesting snow geese without paying any attention to the birds and without disturbing a nest. However, on Baffin Island an Eskimo (Simonie) once killed a bear whose stomach was full of eider duck eggs (C. Jonkel, pers. comm.).

It seems unlikely that scavenging alone could account for the high percentage of sea-birds in the samples from James Bay. We patrolled the beaches and interior of North Twin Island frequently and rarely discovered dead birds.

It appears that in James Bay, polar bears, or, at least certain individuals, have learned to prey on birds. In two separate incidents during late August and early September of 1969, bears were observed to stalk and kill adult geese on the ground in areas of low shrubs (4-6 dm high)(B. Knudsen, pers. comm.). However, this does not explain the high incidence of sea-birds found, especially oldsquaws. It seems apparent that some bears have learned to capture sea-birds on the open sea, probably during the moult. In fact, approximately one half of the scats having remains of birds showed evidence of a moulting condition in the birds at the time of their capture. Polar bears are excellent swimmers and can dive and swim for considerable distances underwater. It seems plausible, therefore, that a bear could dive and rise under a bird resting on the surface, particularly in stormy weather when the shallow seas are roiled, or whenever large breakers are present. In May, 1962, D. Nasogaloak (1971, pers. comm.), an Eskimo hunter, observed a young male polar bear causing a commotion among king eiders in a lead near Banks Island, N.W.T. The bear dived repeatedly, swam underwater, and surfaced in the midst of the flock. Nasogaloak shot the bear and examined the stomach in which he found the remains of 3 king eiders. A similar observation was made

by C. Vibe (1970, pers. comm.) who saw a polar bear enter a lead off Greenland and seize a murre (Uria spp.) by attacking from beneath the surface of the water. Since, as far as we know, no other predators commonly attack birds from the sea in James Bay it may be that they are unwary of attack from this direction.

Other evidence which might support this suggestion is as follows: on several occasions in July, 1968, I watched as polar bears unaware of my presence left North Twin Island to swim in the shallow waters offshore as if hunting. Sea-birds were numerous at the time. Additionally, J. Craighead (1970, pers. comm.) watched a polar bear near the north coast of the island in summer, 1970. For several minutes the bear paid close attention to the movements of a flock of common scoters feeding nearby but did not attempt a stalk.

I could find no good explanation for the great difference in frequency and volume of birds consumed in James Bay as opposed to the mainland. Though accurate estimates of relative numbers are unavailable, Canada geese, oldsquaw, and eiders are common along the Manitoba and Ontario coasts. Large colonies of nesting snow geese (Chen hyperborea) occur on both Cape Churchill and Cape Henrietta Maria, the areas where mainland bears reach their greatest density.

If availability is not an important factor then it is possible that certain bears or perhaps all bears in some areas have learned to catch birds and this phenomenon has become traditional among the James Bay subpopulation. This has likely been true for some time as Doutt (1967) reported finding several scats containing feathers in an expedition to South Twin Island in 1935.

b. Fish (Pisces)

A half dozen vertebrae from a scat collected at West Pen Island was the only evidence of a polar bear having eaten fish. The source could have been carrion from nearby streams or the sea.

Copland (1968) noted from Cartwright's Journals that during one day on the Eagle River, Labrador, in April, 1771, Cartwright counted 32 polar bears fishing for Atlantic salmon (Salmo salar). This is the only region in the world where polar bears have been known to actively prey on fish, as do grizzlies and black bears on the Pacific coast and fish do not appear to form a significant portion of the diet of bears in the Hudson and James bays.

c. Insects

Insects were found in one scat from James Bay and in eight gathered on the mainland, but never in large amounts.

I believe that some insects such as horseflies (_Tabanus_ spp.), the most common insects identified, are licked from the fur during the height of the fly season. I observed heavy horsefly activity around bears in mid-August, 1969, and Jonkel _et al._ (1971) have proposed that one function of summer dens constructed by polar bears is to escape insect harassment.

d. Marine Invertebrates

Marine invertebrates are not mentioned in the literature as food of polar bears. However, marine invertebrates were identified in 14.6% of James Bay scats and 25.5% of those from the coast. Average volumes were not appreciable in either case though this group made up at least 50% volume of each of six scats from James Bay. The differences in frequency and volume between areas were statistically significant. Mussels (_Mytilus edulis_) and sea urchins (_Strongylocentrotus droehbachiensis_) were common in James Bay scats whereas tunicates (Ascidiacea) were most often eaten by mainland bears. Tube worms (Pogonophora) and mussels were also identified in samples from the latter area. Most of these items become available when violent storms carry marine plants and other life forms onto shore.

The invertebrates included under "other miscellaneous

invertebrates" in Table 7 are listed in Appendix VII.

e. Polar bear remains

The frequency of occurrence of remains of polar bears totalled 10.3% and 29.7% in the coastal and James Bay collections, respectively.

Grooming probably accounted for the presence of polar bear hair in those scats in which only small amounts were found. In these instances the hairs were distributed evenly among other food materials. Two scats from each area composed entirely of polar bear remains provided evidence of intraspecific predation or scavenging. The claws of cubs were recovered from one scat in each sample.

In August, 1969, I observed the aftermath of an occurrence of intraspecific predation on the coast of Manitoba. A large male ($\pm$450 kg) was found feeding on the carcasses of a female and two cubs of the year which he had killed several hours earlier.

The stomachs of the victims contained only the remains of ringed seal which suggested they had just left the melting ice pack and were heading inland when attacked by the male, in thick willows about one mile from shore. There were signs of an intensive battle in the area.

The skull of the female had been pierced in three

places by the canine teeth of the male and the masseter muscle was torn loose and protruded from a tear in the skin. The skulls of both cubs were also fractured. One skull definitely showed tooth marks but the other was so badly mangled that it was difficult to determine whether it had been bitten or smashed with a front foot. In all three cases resultant brain damage would have been sufficient to cause death.

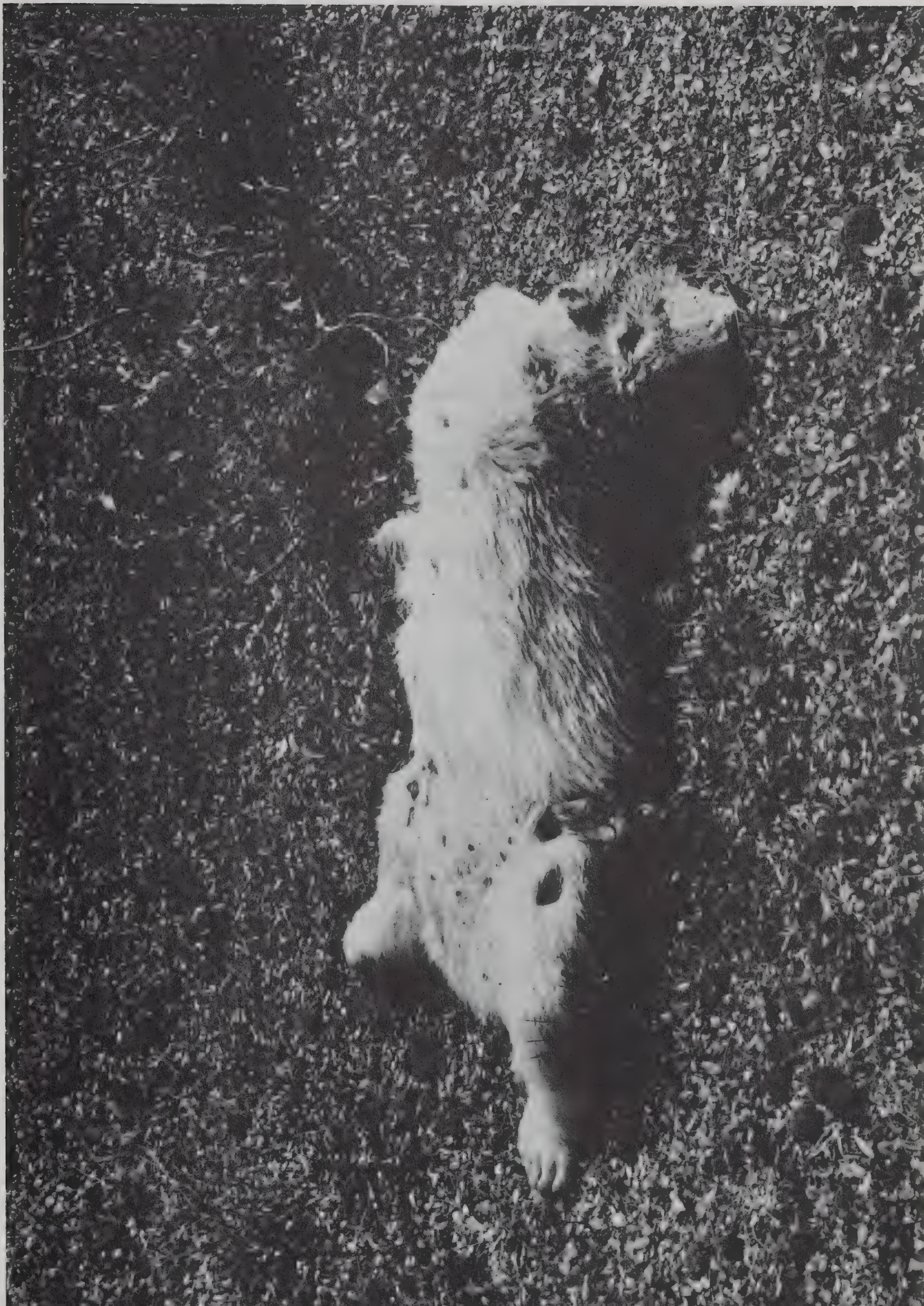
The female weighed 225 kg (Weightape, Ketchum Manufacturing Sales Ltd., Ottawa) and was very fat. The male consumed the fatty tissue and a portion of hide and hair from the chest, abdomen, and the ventral portion of the hind legs (Figure 5). Little muscle tissue was eaten. One cub was 75% consumed (Figure 6); the other had numerous tooth punctures, but had not been fed upon (Figure 7).

There are several notes in the literature describing cannibalism among mountain lions (Felis concolor), usually cases of adult males killing and eating subadults (Young, 1927; Lesowski, 1963; Hornocker, 1970). Elsey (1954) described a similar occurrence in Canada lynx (Lynx canadensis) and Marhenke (1971) observed an incident in which four wolves (Canis lupus) killed (but did not consume) a lone wolf in Alaska. Tisch (1961) found the remains of

Figure 5. Remains of female polar bear killed by an adult male polar bear on the coast of Manitoba.

Figure 6. Remains of one of two cubs killed by an adult male polar bear on the coast of Manitoba.

Figure 7. Remains of second of two cubs killed.



a cub in a black bear scat. Two accounts of predation of black bears by grizzlies are described by Russell (1967).

It is not clearly understood why intraspecific predation occurs among certain species. In this instance the male bear involved appeared to be healthy. On several other occasions we have seen evidence of strife among polar bears along the Hudson Bay coast. This usually consisted of cuts from claws or teeth, lameness, and in one case, a broken jaw sustained by an adult male, apparently the result of a fight. Such strife, which sometimes results in cannibalism, may be an expression of a population control mechanism brought about by a high density of polar bears on the coast of Manitoba in summer and autumn, as suggested by Jonkel (1970b).

f. Seals (Phocidae)

The frequency of seal remains was identical for the two regions compared. Only ringed seal and bearded seal are common in James and Hudson bays (Mansfield, 1967). Diagnostic vibrissae and claws of ringed seals appeared in one James Bay and six mainland scats. Bearded seal vibrissae and claws were found in six samples from North Twin and one from the coast.

It was common to find vegetation, usually grass,

mixed in with seal, suggesting that the seals had been eaten in summer. Since it is unlikely that polar bears can capture and kill seals in open water, the remains in these cases were probably carrion.

g. Small mammals (Cricetidae)

Apparently there are no small mammal populations resident on North Twin Island. A small trapping program in July, 1968 failed to yield a single specimen, nor did I find any burrows or droppings. This conclusion is supported by the complete absence of small mammal remains in scats gathered on the island. This was not the case on the mainland where microtines occurred in 20.3% of the samples, a statistically significant difference from the James Bay samples. Muskrats (*Ondatra zibethicus*) and meadow voles (*Microtus pennsylvanicus*) were the only microtines identified.

Polar bears can catch dispersing juvenile muskrats along the mainland coast in October when numerous, shallow, "slot" lakes freeze. In October, 1969, in temperatures near -10C. at Fort Churchill, I watched a young muskrat burrow under the ventral fur of a polar bear which was immobile from drugs administered several hours earlier. Had the bear been resting normally, the muskrat would have

been easy prey.

In the Canadian arctic bears may feed on lemmings (Dicrostonyx groenlandicus; Lemmus trimucronatus) when they are abundant, according to Harington (1965), and in the early 1960's Churchill residents observed bears feeding at will on lemmings in a year when lemmings were particularly abundant. P. Taylor (pers. comm.) observed a bear digging for collared lemmings in 3-10 dm of snow on Bathurst Island in May, 1969. Pedersen (1962) stated that polar bears catch lemmings by turning over stones under which they are hiding. However, none were found in my samples, probably because lemmings appeared to be low in numbers during the study.

ii. Plant remains

a. Berries and other fruits

The frequency and volume of berries and other fruits in the two areas differed significantly (Figures 2 and 3). Frequencies were 39.1% versus 2.8% for the James Bay and mainland samples and volumetric totals were 15.2% and 0.6%. Availability probably accounted for much of the difference. Crowberries (Empetrum nigrum), which accounted for most of the berries in the scats, are abundant on North Twin, whereas much of the immediate coastline of the mainland features sand dunes where there is considerable drifting,

or low marshy tide flats, neither of which are suitable for shrubs like crowberry or *Vaccinium* spp. Further inland on the mainland I have observed polar bears feeding extensively on both berries.

Fruits of *Juniperus communis*, recorded in 14 scats in James Bay were the second most frequent fruit. Berries and seeds of *Vaccinium*, *Arctostaphylos*, *Pyrola*, and *Oxytropis* occurred infrequently.

b. Club moss (Lycopodiaceae)

Lycopodium spp. was found in seven samples, all from James Bay. This genus grows prolifically in the wind-shade areas of the moraine where summer denning is common. It seems safe to assume that the bears may ingest bits of *Lycopodium* while digging dens or cleaning their fur.

c. Eelgrass (Potamogetonaceae)

Eight percent of mainland scats contained eelgrass (*Zostera marina*) while none was recorded in James Bay. One scat was composed entirely of this pondweed, which grows in shallow salt water. In my study areas eelgrass is common only along the coast of Manitoba between Cape Churchill and York Factory where it was found in droppings.

d. Grasses (Gramineae)

Consumption of grasses (abundant throughout both study areas) by polar bears in James Bay differed significantly from that on the mainland. Grasses occurred with a frequency of 26.7% in 233 scats from the island as compared with 80.2% for the mainland (Figure 2). A similar difference is evident in volume indices of 12.1% and 42.8% for the respective samples (Figure 3).

Elymus arenarius is conspicuous by its presence in both series of samples. It is a large, coarse grass and easily identified even in the absence of blossoms. The blossoms (spikes) of *Elymus* were sometimes exclusively selected for food. Five scats collected on the mainland were composed solely of these blossoms, apparently eaten just prior to maturation of the seeds. Carbohydrates are in much higher concentration in seeds than in the culm and leaves of grass and bears may have selected the spikes for this reason.

Other species of grass identified were *Calamagrostis canadensis*, from James Bay and *Hordeum jubatum*, *Poa alpigena*, *Festuca rubra*, and *Trisetum spicatum* from the mainland. Lønø (1957) documented the occasional appearance of grasses in 172 stomach samples examined in Svalbard. Loughrey (1956) and Pedersen (1962) also mention grasses as

a source of food for polar bears and I have observed bears grazing on grass on several occasions on both North Twin Island and the mainland.

Polar bears may seek grasses even when animal foods are plentiful. Koettlitz (1898) once observed a bear feeding on a seal, then immediately travel three miles to graze on grass, which it ate in quantity. He also examined the contents of 30 stomachs and recorded grasses in eight of them, two having grass in combination with remains of seal. I once watched a grizzly bear (July, 1962) in the Rocky Mountains which frequently interrupted ingestion of carrion to feed on nearby vegetation.

e. Horsetail (Equisetaceae)

Trace amounts of Equisetum were recovered from two scats collected in James Bay. No other evidence of feeding on this group of plants was found. Tisch (1961), by comparison, found this genus an important component of black bear diets.

f. Leaves and stems of shrubs and broad-leaved herbs

Leaves and stems of shrubs and broad-leaved herbs occurred with a high frequency on North Twin Island (67.4%) but in volumetric terms were quite low, amounting to 3.5%. Except for stems and leaves of Empetrum, which were

apparently consumed in the process of foraging for berries, leaves and stems of other plants were found in trace amounts only. In many cases I believe these items were eaten accidentally during the ingestion of other foods. Alternately, some may have been consumed during grooming, or some may have adhered to the scat after deposition.

Leaves and stems were noted in 21.7% of the mainland samples, mostly in trace amounts, and again this was significantly different from James Bay scats. The lower frequency compared to North Twin may be a result of fewer shrubs near the coastline of the mainland.

Salix spp., *Empetrum nigrum*, *Betula glandulosa*, and *Vaccinium* spp. figured most prominently among leaves and stems identified from the James Bay samples while *Salix* spp. and *Saxifraga tricuspidata* were most commonly recorded in samples from the mainland.

g. Lichens

Lichens were found in 18% of the scats gathered on the island and in 2.8% of the scats collected on the mainland. These percentages were significantly different by Chi-square test. In all but one scat, only trace amounts were present. When dry, lichens such as *Cetraria islandica*, which is common on North Twin, would easily cling to polar

bear hair. Therefore, it is quite probable that their presence in the feces resulted mainly from grooming. In only one scat (mainland) was I reasonably certain that lichens had been deliberately consumed. Schein (1962) reported that lichens are a source of summer food for Svalbard polar bears, but did not quantitatively document this.

Appendix VIII consists of a list of names of lichens from my collections.

h. Marine algae

Another interesting comparison in the amounts of specific types of food consumed by polar bears of James Bay and those from the mainland can be made with respect to marine algae. The frequency and volume indices for all species of seaweed for North Twin were 14.2% and 4.4%, respectively. For the Manitoba and Ontario coasts the figures were 70.8% and 40.6%, respectively (Figures 2 and 3). Again the differences were statistically different by Chi-square test. This gross difference in food habits between the two subpopulations cannot be attributed to availability of marine algae, as *Fucus* and *Laminaria* are abundant throughout both areas. It may be that the greater utilization of birds by island bears somehow makes it

unnecessary for them to rely as much on seaweed and grass as a source of food. Alternately, it is possible that though sea-birds may be available in both areas, they may be more vulnerable at North Twin. Perhaps the wind is more effective in disturbing island waters or the turbidity is greater in James Bay, making it easier for bears to hunt sea-birds around the islands.

Significantly more brown algae (Phaeophyta) was used in both areas when compared volumetrically with red algae (Rhodophyta) and green algae (Chlorophyta). However, there is a regional difference in utilization of brown and red algae on the coast and this will be discussed below.

Among brown algae, _Fucus_ and _Laminaria_ were the most common species in scats from both areas. _Desmarestia aculeata_ and _Sphacelaria_ spp. were also identified. Substantial amounts of red algae were recovered from mainland scats but only one sample collected in James Bay revealed a trace of Rhodophyta. This is most likely due to the scarcity of red algae from James Bay waters (R.K.S. Lee, pers. comm.). _Neodilsea integra_ and _Rhodymenia_ spp. were the two species of red algae which appeared most often. Green algae were not consumed to any degree in either area.

Considerable variation in amounts of Phaeophyta and

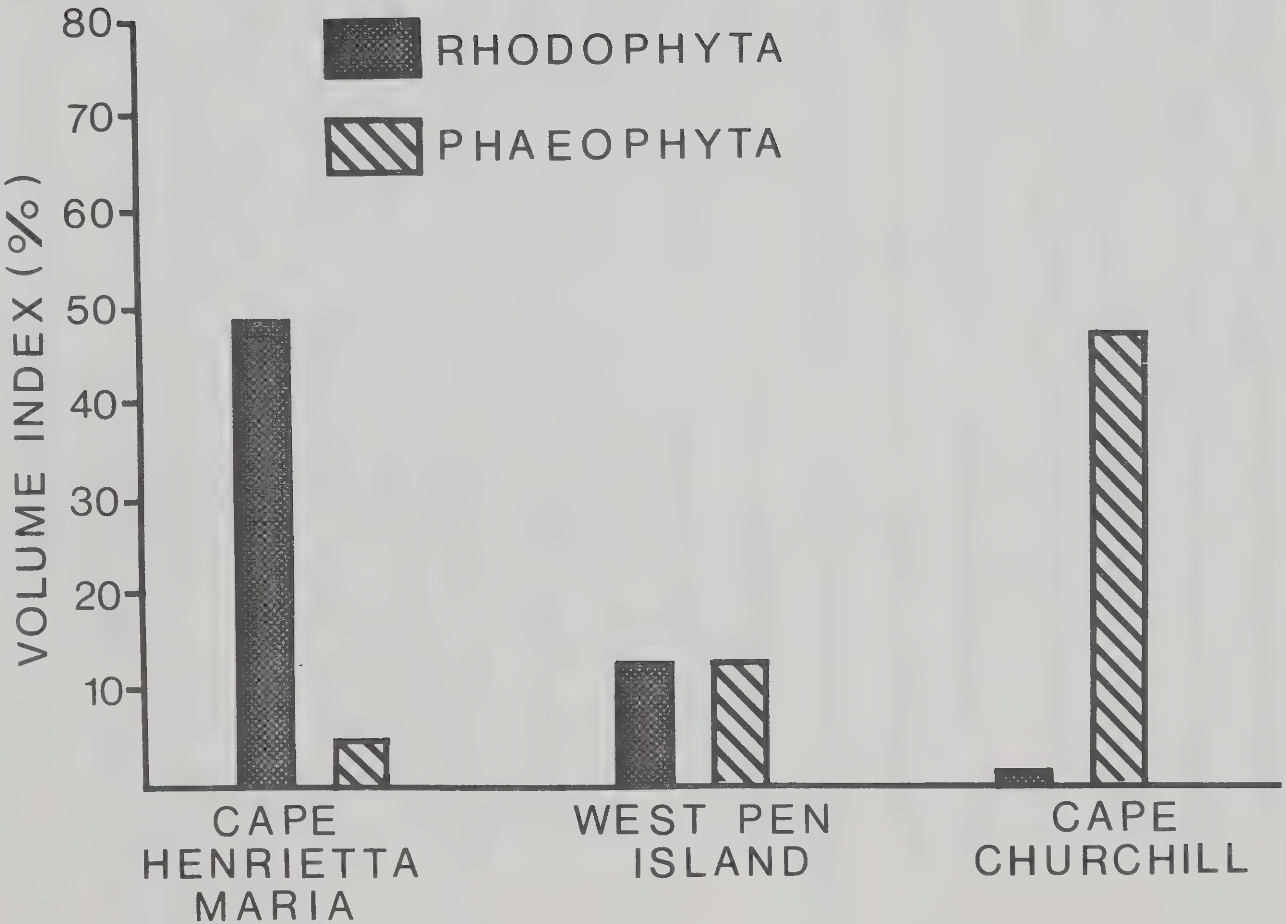
Rhodophyta existed among samples collected at Cape Henrietta Maria, West Pen Island, and Cape Churchill (Table 5, Figure 5). Phaeophyta made up a significantly larger portion of seaweeds present in 86 scats gathered at Cape Churchill while the opposite is true of Cape Henrietta Maria where Rhodophyta dominated in a sample of 48 scats. At West Pen Island (78 scats) the volumes of both groups were nearly equal. The amounts of Phaeophyta deposited on beaches by the action of storms indicated that this group is common throughout southwest Hudson Bay. However, the more fragile species of Rhodophyta were not conspicuous on beaches -- even at Cape Henrietta Maria where they were prominent in scats. It may be that polar bears prefer red to brown algae and that the former are abundant only in sub-tidal waters along the Ontario coast, thus accounting for the difference in levels of consumption between areas. Alternately, polar bears in these regions may have developed different preferences over a period of time.

Use of marine algae by polar bears has also been recorded in the High Arctic. Tsalkin (1936) found Laminaria spp. in three of 145 stomachs collected on the Franz Josef Archipelago. On Svalbard Lønø (1970) once watched a female and yearling dive into 3-4 m of water from an ice floe; they

Table 8. Frequency and volume indices for Phaeophyta and Rhodophyta in scats collected at three sites on the coasts of Manitoba and Ontario. Sample size in parentheses.

Algae/Site of Collection	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.	Frequency Index (%)	Volume Index (%)
Phaeophyta:								
Cape Henrietta Maria and vicinity (48)	-	-	-	3	6	15	50.0	5.1
West Pen Island and vicinity (78)	2	2	2	7	14	12	50.0	13.1
Cape Churchill and vicinity (86)	18	10	12	9	14	15	90.7	47.0
Rhodophyta:								
Cape Henrietta Maria and vicinity (48)	11	14	-	-	1	-	54.2	48.7
West Pen Island and vicinity (78)	-	4	7	4	3	4	28.2	12.9
Cape Churchill and vicinity (86)	-	1	-	1	-	3	5.8	1.6

Figure 8. Volume indices of Phodophyta and Phaeophyta found in scats at three sites.


RHODOPHYTA
PHAEOPHYTA
VOLUME INDEX (%)
80
70
60
50
40
30
20
10
CAPE HENRIETTA MARIA
WEST PEN ISLAND
CAPE CHURCHILL

hauled large quantities of the vegetation onto the ice, picked through it, and apparently ate the most preferred parts. In August 1970, B. Knudsen (pers. comm.) observed a large male diving for *Fucus* in open water off North Twin Island. The bear was in shallow water so that he could stand on the sea floor. He held the food in his forepaws and ate the thalli, casting away the stipites.

Much of the seaweed eaten may be obtained by diving and pulling it from the substrate, which is apparently similar throughout both areas. This is especially probable with respect to red algae of which *Neodilsea integra* and *Rhodymenia* are sub-tidal. On examining specimens of marine algae picked from scats, R.K.S. Lee (1970, pers. comm.) noted that most appeared to have been eaten in fresh condition, as they did not show the abrasion that one would expect of algae which had been washed up on the beach. Macroscopically, most marine algae found in the scats appeared relatively unaltered by digestion. Therefore, it is possible they were eaten as a source of vitamins or minerals or for bulk to ease hunger pangs. More is said about this in the concluding discussion.

i. Mosses

Though mosses do not appear to be a major food source

(volumes of 2.6% and 2.2% for James Bay and the mainland respectively), they are occasionally consumed in fairly large quantities at one feeding period. Six scats from North Twin and seven scats from the coast contained amounts of moss in excess of 25% volume. Two scats from James Bay consisted entirely of moss. At least one of the samples containing large amounts of moss was deposited on top of the snow in early April.

Appendix IX consists of a list of a list of names of mosses from my collection.

j. Mushrooms

Frequency indices for mushrooms in James Bay and mainland samples were 8.2% and 1.9%, respectively, a statistically significant difference. Volumes also differed significantly but were not appreciable in either region. It appeared that mushrooms were usually eaten in conjunction with crowberries. Mushrooms are numerous on the tundra of islands in James Bay in late summer. Most specimens were from the Agariaceae and a few from Boletaceae families.

k. Sedges (Cyperaceae)

Surprisingly, sedges were not conspicuous in scats from either area, though they grew abundantly in both. With the high incidence of grass, one might expect to find sedges

in greater evidence. The only specific identification was of *Carex saxitalis* in one scat collected on the mainland. Tisch (1961), on the other hand found sedges to be extensively consumed by black bears, particularly in spring when up to 28 percent of droppings contained sedges. Similarly, Clark (1957) considered sedges one of the most common foods of Kodiak bears (*U. arctos*).

iii. Miscellaneous items

Interestingly, sand was present in substantial portions of five scats analyzed from North Twin. Three of these were collected at the entrance to a polar bear den. The substrate here was almost pure sand and it seems reasonable to assume that the bear licked the sand from his coat during or after digging the den or consumed it accidentally while tearing roots from the den. The sand was mixed with vegetation such as herbaceous leaves and *Lycopodium* which may also have been consumed in the manner described above.

Styrofoam appeared in six scats -- all collected on the mainland. It probably was found by the bears as jetsam on the beaches, as I frequently observed chunks washed ashore. Why bears consume this substance in relatively large quantities is unknown.

Chips of wood were discovered in 26 scats (12.3%) from the coastline and in five (3.0%) from James Bay, a statistically significant difference. Most appeared to have originated from driftwood. It is not known why bears would sample this fare. Lønø (1970) reports finding pieces of wood in two of 172 stomach samples at Svalbard.

Single occurrences of cardboard, tire rubber, and plastic ribbon were doubtless picked up from the beaches. Lead shot was found with Canada goose feathers in a James Bay scat and had probably been embedded in the bird. Many such items plus a large number of foreign food items occurred in scats collected near the Ft. Churchill garbage dump, but were not included in these analyses (Appendix VI).

Concluding Discussion

The polar bears of Hudson and James bays, whose summer and autumn food habits were examined in this study, represent the most southerly population of this species in the world. Unlike polar bears elsewhere, they must spend a substantial period (3-5 months) on land when the sea ice melts.

In my study area, polar bears of all age classes appear to gain weight from mid-winter to early summer and thereafter, gradually lose weight or remain stable through late summer, autumn, and early winter (C. Jonkel, pers. comm.). The spring period of rapid weight increase probably coincides with the birth of ringed and bearded seals which are easy prey for polar bears. This pattern contrasts sharply with seasonal growth of black bears in Montana where Jonkel (1967b) found that all age classes of black bears either lost weight or gained weight slowly during spring and early summer. From mid-July until denning the weight gain of black bears was rapid in all age and sex classes. Consequently with the early seasonal peak in weight of polar bears, summer food could be significant in determining the condition in which bears, especially sub-adults, enter winter. Presumably those bears obtaining

additional food in summer and autumn would show the least deterioration or greatest gain in general condition and would have an advantage in meeting the rigors of winter.

Tagging data supplied by the Canadian Wildlife Service suggest that polar bears resident in James Bay and those ranging along the coast of Manitoba and Ontario represent fairly distinct subpopulations. Results from aerial surveys show that the summer distribution of polar bears on the mainland varies with sex and age. The majority of bears frequenting the promontories of coastal zones are adult males, while fewer numbers of sub-adults and females with cubs are found along the coast between groups of males. Those found further inland represent a more even mixture of all age and sex classes. In this study, data from the mainland best reflect the food habits of coastal bears (biased toward adult males) rather than those spending the summer further inland. In certain years at least, all sex and age classes of bears are evenly represented on the central and north islands of James Bay. It is conceivable that this might account for my observed differences in food habits of James Bay and mainland subpopulations of polar bears but I do not consider it likely.

Overall, polar bears in Hudson and James bays, like

other species of bears, are omnivorous. Scat analyses showed that their diets vary widely from area to area. Some of the more common foods identified were: birds, seals, microtines, mussels, sea urchins, tunicates, marine algae, grasses, berries, shrubs, broad-leaved herbs, mosses, and mushrooms.

Comparison of results of scat analyses for bears from James Bay with those for bears from the mainland show considerable differences in kinds of foods consumed. Birds (primarily oldsquaw) were the food most commonly in scats from bears in James Bay, while grasses and marine algae were most often found in scats from bears frequenting the mainland. Berries and other fruits are also eaten in significantly greater quantities by the island bears as opposed to their mainland counterparts. In contrasting both the frequency and volumes with which the afforementioned foods are consumed by the two groups of bears, the differences are great.

The differences between foods of animal and plant origin, in terms of protein, fat, and carbohydrate content, are considerable. A diet of sea-birds, for example, provides roughly four times as much protein and eight to ten times as much fat as most grasses (Canada Department of National Health and Welfare, 1960; McDonald et al.,

1966). By contrast, carbohydrates are low in seabirds while substantial amounts are available in grasses (Canada Department of National Health and Welfare, 1960; Crampton and Lloyd, 1959). Berries, grass seeds, and other fruits are especially rich in carbohydrates.

In general, the caloric content of birds is two to three times greater than that of most plants available to polar bears. Marine algae is very low in carbohydrates, and in protein. However, they are rich in trace elements and a good source of vitamins, possibly helping animals consuming them to exploit the proteins and calories in the rest of their diet (McInnes, 1955; Stephensen, 1968).

On the basis of this information I would predict that the diet of James Bay polar bears better prepares them for winter than that of mainland subpopulations. The high intake of carbohydrates compared to proteins and fats by the latter provides a direct source of energy but proteins and fats consumed by the former can be stored as a future source of energy as well as utilized directly.

Since food habits of both subpopulations vary markedly, summer and autumn diet may not be an important factor in limiting numbers of polar bears. This possibility arises because preliminary evidence suggests that polar bears in both James Bay and along the mainland are generally in very

good physical condition (C. Jonkel, pers. comm.), even though the former appear to be on a high protein diet and the latter on a diet high in carbohydrates. Both subpopulations appear to be maintaining their numbers and are, perhaps, increasing.

The Hudson and James bay regions are largely unexplored in a biological sense. Therefore, it is difficult to speculate to what degree availability of various food items accounts for the variations in diet between the two subpopulations. Certainly it explains some of the differences. However, such foods as birds (Canada geese, oldsquaw, eiders), brown algae, and grasses appear to be abundant throughout the whole area. There is, nevertheless, selection for or against certain items in both areas. I believe that learning and preference may account for some of the differences in frequency and volumes of certain foods eaten. For example, certain bears in James Bay may have learned to catch sea-birds on the open sea in the past and have since transmitted this ability culturally to subsequent generations. My studies therefore confirm that the subpopulations of James Bay and the mainland are to some extent discrete. Further studies of movement and behaviour should substantiate my conclusions.

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Appendix I

In 1969 a major winter denning area was discovered near York Factory, Manitoba (Jonkel et al., 1971). During investigations in this region in March, 1970, eight fresh scats were collected from the snow surface and later analyzed (Table 9). On emerging from their dens in March the females remain in the vicinity for several days or weeks until their cubs are strong enough to travel out onto the sea ice. During this period, the females dig through snow up to 1 meter deep for food. Grasses and mosses were consumed in greatest quantity. This is similar to the findings of Uspenski and Chernyavski (1965) at Wrangel Island, U.S.S.R. where females emerging from dens in mid-March fed upon willow branches, grasses, and mosses.

There are three possible reasons why this fare is consumed: 1) for its food value (which is low), 2) for bulk to ease hunger pangs or 3) as a source of vitamins and minerals which may be deficient after the denning period.

The polar bear hair, which made up more than 25 percent of two samples, likely resulted from grooming. The hair was the fine, kinky type of very young cubs and the female probably licked it off the coats of her offspring.

Table 9. Items identified in eight fresh scats collected at winter dens of female polar bears near York Factory, Manitoba. March, 1970.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.
ANIMAL REMAINS						
Insecta	-	-	-	-	-	1
Ursus maritimus	-	-	-	2	-	2
PLANT REMAINS						
Fresh water algae	-	-	-	1	-	1
Gramineae	2	-	2	1	2	1
Leaves and stems of shrubs and broad-leaved herbs	-	-	-	-	1	5
Lichens	-	-	-	-	-	2
Mosses	-	2	1	1	2	1
Needles and bark of conifers	-	-	-	-	-	2
Wood chips	-	-	-	-	1	2

Appendix II.

Two fresh scats were picked up in mid-August, 1969, at a summer den of an adult male polar bear near York Factory, Manitoba, about 25 km inland (the same area referred to in Appendix I.). One of them was composed almost entirely of horseflies (Table 10). These insects were very numerous at that time and the bear likely licked them from his coat. The second scat consisted mainly of eelgrass. Since eelgrass grows in shallow salt water, it must have been consumed just prior to the male's migration inland.

Table 10. Items identified in two fresh scats collected at a summer den of an adult male polar bear near York Factory, Manitoba. August, 1969.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.
ANIMAL REMAINS						
Tabanus spp.	1	-	-	-	-	-
Ursus maritimus (hair)	-	-	-	-	-	1
PLANT REMAINS						
Bark of conifers	-	-	-	-	-	1
Gramineae	-	-	-	-	1	1
Leaves and stems of broad-leaved shrubs and herbs	-	-	-	-	1	1
Mosses	-	-	-	-	-	1
Zostera marina	-	-	1	-	-	-

Appendix III.

Fourteen scats were collected in the vicinity of a game bird hunting camp at Watson's Point (near Fort Churchill), Manitoba. The results of analysis (Table 11) were not included in the mainland samples because of the high incidence of garbage. In addition to items like plastic bags, tinfoil, etc., I believe all or most of the remains of birds (snow geese and willow ptarmigan, *Lagopus lagopus*) were scavenged from camp garbage as only remains of heads and wings were recovered.

Table 11. Items identified in 14 scats collected at Watson's Point, Manitoba. October, 1968.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.
ANIMAL REMAINS						
Aves (feathers and bones)	4	3	3	1	1	-
Aves (egg shells)	-	-	-	-	-	1
Cricetidae	-	-	-	-	-	2
PLANT REMAINS						
Gramineae	-	-	1	-	2	1
Leaves and stems of broad-leaved shrubs and herbs	-	-	1	-	1	9
Lichens	-	-	-	-	-	2
Marine algae (<u>Laminaria</u> spp., <u>Neodilsea</u> spp., <u>Laminaria</u> spp.)	1	-	-	-	2	1
Mosses	-	-	-	-	1	3
MISCELLANEOUS						
Cardboard	-	-	-	-	1	1
Cloth	-	-	-	-	1	-
Plastic bags	-	-	-	-	3	-
Tinfoil	-	-	-	-	-	1

Appendix IV.

In mid-October, 1968-69 a total of five fresh scats were collected from four bears captured in snares near Fort Churchill. These animals were trapped at distances ranging from 12-40 km from the Fort Churchill garbage dump so most of the foods consumed were from natural sources, e.g. grasses, marine algae (Table 12). The egg shells and bones and feathers of birds may have been scavenged from a nearby hunting camp.

Table 12. Items identified in five fresh scats collected from four bears captured near Fort Churchill, Manitoba. October, 1968-69.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.
ANIMAL REMAINS						
Ascidiaceae	-	-	-	-	-	1
Aves (feathers and bones)	-	-	1	1	-	1
Aves (egg shells)	-	-	-	1	-	-
Cricetidae	-	-	-	1	-	-
Ursus maritimus (hair)	-	-	-	-	-	1
PLANT REMAINS						
Berries (*Empetrum nigrum*)	-	-	-	-	1	1
Gramineae	1	1	-	1	-	-
Leaves and stems of broad-leaved shrubs and herbs	-	-	-	-	3	1
Marine algae	-	-	-	2	-	1
Mosses	-	-	-	-	-	2
Wood chips	-	-	-	-	-	1

Appendix V.

Five scats were collected at Coats Island in Hudson Bay, 700 km northeast of Cape Churchill. Only traces of animal material were found (Table 13). Vegetation made up the rest of the samples, of which marine algae and mosses were most conspicuous by volume.

Table 13. Items identified in five scats collected at Coats Island, N.W.T. August, 1967.

Items Identified	No. of Occurrences/Volumetric Category 100-95%	95-75	75-50	50-25	25-5	5-Tr.
ANIMAL REMAINS						
Ursus maritimus (hair)	-	-	-	-	-	1
Unidentified bone fragment	-	-	-	-	-	1
PLANT REMAINS						
Berries (*Empetrum nigrum*)	-	-	-	-	-	1
Cyperaceae (*Draba lactea*)	-	-	-	1	1	-
Gramineae (*Elymus arenarius*)	-	-	1	-	-	-
Juncaceae (*Luzula* spp.)	-	-	-	-	1	-
Marine algae (*Desmarestia* spp., *Fucus* spp., *Laminaria* spp., *Sphacelaria* spp.)	1	-	1	1	-	-
Mosses	-	1	1	-	1	-
Leaves and stems of broad-leaved shrubs and herbs	-	-	-	-	1	2
Lichens	-	-	-	-	-	1

Appendix VI.

A total of 11 scats were collected near the garbage dump at Fort Churchill, Manitoba, in autumn 1968-69. They were composed almost entirely of remnants of human food and assorted inorganic items scavenged from a nearby garbage dump. The results were not quantified. In only three samples were small amounts (less than 10 percent by volume) of natural foods identified; these being grass, marine algae, and crowberries. Items identified as garbage included beans, corn, beets, potatoes, peas, pickles, cherry pits, pineapples, bacon rinds, ham, unidentified feathers, fragments of bone, egg shells, plastic bags, paper, cheesecloth, wood chips, and fragments of metal, bakelite, and porcelain. This confirms that polar bears, like other species of bears, will feed extensively on garbage when available.

Appendix VII.

The following organisms are included under the heading "other miscellaneous invertebrates" in Table 7. It is probable they were accidentally consumed as all were found in trace amounts in scats composed primarily of seaweed.

Acmaea testudinalis (limpet)
Balanus spp. (barnacle)
Crenella faba
Littorina saxitilis (snail)
Macoma balthica (clam)
Polybrachia spp.

Appendix VIII.

The following lichens were identified in scats from James Bay (Table 6) and from the coasts of Manitoba and Ontario (Table 7).

James Bay:

Alectoria nitidula
A. ochroleuca
Cetraria cucullata
C. islandica
C. nivalis
Cladonia gracilis
C. mitis
C. rangiferina
Cladonia spp. (subgenus *Cladina*)
Cornicularia divergens

Mainland:

Cladonia gracilis
Lecanora epibryon
Xanthoria elegans

Appendix IX.

The following species of moss were identified in scats from James Bay (Table 6) and from the coasts of Manitoba and Ontario (Table 7).

James Bay:

Aulacomnium palustre
Bryum spp.
Calliergon giganteum
C. stramineum
Cinclidium stygium
Dicranum elongatum
Drepanocladus lycopodioides
Hylocomium splendens
Mnium blyttii
M. rugicum
Paludella squarrosa
Pleurozium schreberi
Polytrichum juniperinum
P. strictum
Ptilium crista-castrensis
Rhytidium rugosum
Scorpidium scorpoides
Tomenthypnum nitens
Tortula ruralis

Mainland:

Aulacomnium palustre
Brachythecium spp.
Bryum spp.
Campylium stellatum
Ceratodon purpureus
Dicranum angustum
D. undulatum
Drepanocladus uncinatus
Leptodictyum riparium
Pleurozium schreberi
Rhytidium rugosum
Sphagnum spp.